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ENDODONTIC RESIDENTS' UNDERSTANDING OF BIOSTATISTICS: A 2010 SURVEY OF ENDODONTIC RESIDENTS IN THE UNITED STATES

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This is to certify that the thesis prepared by Paul LeTellier Jr entitled "Endodontic Residents' Understanding of Biostatistics: A 2010 Survey of Endodontic Residents in the United States" has been approved by his committee as satisfactory completion of the thesis requirement for the degree of Master of Science in Dentistry

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

by

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

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Endodontic residents must keep current with clinical information to practice evidence-based dentistry. To do so, endodontic residents must access research papers and interpret results. This requires a knowledge of biostatistics. However, the biostatistical knowledge of endodontic residents is relatively unknown. The purpose of the study was to assess the biostatistical knowledge of endodontic residents using a survey instrument to prove or reject the hypothesis that there exists a lack of understanding of biostatistic principles among endodontic residents. A survey consisting of 29 questions querying attitudes and biostatistical knowledge was distributed to 230 endodontic residents and returned with a 32% response rate. The overall mean resident

knowledge score was 42.3% (SD, 17.5%; range, 10% to 90%). Only 39% stated they understood all of the statistical terms encountered in journal articles. This data supports the hypothesis that there exists a lack of understanding of biostatistical principles and would suggest that more effective training in biostatistics in residency education is desirable.

Introduction

Evidence-based dentistry attempts to answer the clinical question "what is the best clinical action given this patient's clinical problem" by integrating the best available research evidence, the experience and expertise of the practitioner, and the patient's values to make a clinical decision based on science (1-3). The concept of evidence-based dentistry was introduced in the late 1990s (1,3-5). Prior to this, opinions were formed based upon clinician's personal and professional observations rather than upon scientific data. Unfortunately, these observations were often misleading and unsubstantiated. Discussion of the clinical problem with patients and professional colleagues center on these empirical opinions. Today, a practitioner's clinical actions should be supported with the best scientific data available. Communication with professional peers and patients should be based on sound scientific information (6).

Practicing evidence-based dentistry requires data and the ability to understand and interpret data. A practitioner must be able to access and acquire databases and journal articles which provide research evidence. The practitioner should be able to understand the materials and methods of the research, the statistical analysis of the data obtained, and the conclusions derived from the data. The comprehension of biostatistics is a critical factor in the practitioner's ability to identify the best available research evidence. Furthermore, the practitioner must be able to transfer the understanding of the best available evidence or research to clinical practice (2,7).

The practice of evidence-based dentistry is supported by the American Dental Association (ADA). The ADA position on evidence based dentistry states, "Evidence-based dentistry is an approach to oral health care that requires the judicious integration of systematic

assessments of clinically relevant scientific evidence, relating to the patient's oral and medical condition and history, with the dentist's clinical expertise and the patient's treatment needs and preferences." The ADA's definition of scientific evidence is "information obtained from randomized controlled clinical trials, non-randomized controlled clinical trials, cohort studies, case-control studies, crossover studies, cross-sectional studies, case studies, or the consensus opinion of experts in appropriate fields of research" (8).

In medicine, information has been obtained regarding interpretation of evidence-based medicine and statistical theory. Several studies of practicing medical physicians in the 1980s showed most physicians possessed a poor understanding of common statistical tests and displayed a limited ability to interpret study results (9-12). Reportedly, practitioners were only able to understand the analysis and interpretation of the results in 21% of the research articles presented (9,13). With more complex statistical tools used today in research articles, many physicians are likely to have increased difficulty in understanding and applying evidence-based medicine.

A 2009 survey of Italian physicians was conducted to determine their knowledge, attitudes, and professional use of randomized clinical trials and meta-analyses. Sixty-one percent of the respondents agreed that meta-analyses were able to evaluate the efficacy of the health interventions yet only 50.8% of the respondents were able to correctly identify more technical biostatistical related questions. A low level of knowledge of biostatistics was evident. Interestingly, most Italian physicians did not incorporate the use of meta-analysis results into their clinical practice (14).

In 1987, a survey of fifth year surgical residents found that 92% of the residents received less than five hours of statistical instruction during their entire residency. Upon examination of the degree of statistical comprehension, the rankings indicated the surgical residents' maintained a suboptimal knowledge of statistics (15,16). A follow up study in 2000 analyzed a structured curriculum for improved resident education in statistics and evidence based medicine knowledge. The study surveyed 62 surgical residency programs and revealed that only 33% of the programs offered formal statistics teaching in their curricula. For the study, a structured biostatistical curriculum was established and presented to surgical residents. After the lectures were completed, a significant increase in biostatistical understanding was displayed. The authors concluded that a structured curriculum in statistics was critical and essential to any residency's core curriculum and to the resident's success in practicing evidence-based medicine (16).

A recent survey of internal medicine residents' understanding of biostatistics and results in the medical literature was conducted in 2007 by Green et al. The survey concluded that most residents possessed a poor understanding of biostatistics required to interpret many of the results published in clinical research. The study further concluded that a more effective biostatistics training curriculum was necessary to prepare internal medicine residents for practicing evidence-based medicine (9).

In dentistry, little information has been obtained regarding interpretation of evidence-based dentistry and statistical theory. Currently, dental education in the United States purports to be moving toward an evidence-based dentistry philosophy. Kassebaum et al in 2007 surveyed curriculum changes in United States and Canadian dental schools. This survey revealed that most

dental schools in the United States and Canada have changed very little in the application of an evidence-based dentistry curriculum (17,18). In fact, 77% of dental schools were still organized along the traditional discipline boundaries (17,18). A general understanding and comprehension of technical terms used in evidence-based dentistry among dental students may be poor due to a curriculum lacking in evidence-based dentistry applications.

Very little information has been obtained on the practitioner's, the resident's, or the dental student's knowledge in evidence-based dentistry or their ability to understand information contained in scientific articles. At present few studies have been conducted to survey a dental resident's knowledge of biostatistics or perception of biostatistics as a means to infer whether evidence-based dentistry is being practiced. The purpose of this research was to survey a specific subset of residents, endodontic residents, to determine their perception of and knowledge related to biostatistics.

Material and Methods

To evaluate the understanding of biostatistics in graduate endodontic programs across the United States, a survey was constructed based on a previous survey by Green et al in 2007 (12). Survey questions were modified to pertain to dentistry. The study protocol was approved by the Virginia Commonwealth University Institutional Review Board #HM12456.

An invitation to the survey was distributed to 230 endodontic residents in 30 accredited endodontic programs in the United States. To obtain graduate endodontic residents' email addresses, graduate endodontic program directors were contacted via e-mail regarding e-mail addresses of current endodontic residents to be used in the survey (Appendix A). The e-mail addresses of the program directors is public information obtained from the American Association of Endodontists' directory. Participation of the program directors and the endodontic residents was optional. Endodontic residents were excluded from the survey if permission was not obtained from program directors for inclusion in the survey. The survey was submitted to the available residents' emails along with an introductory letter to the survey (Appendix B). The residents who responded were directed to a University web site where the survey was administered online using the Inquisite Survey Software (Version 8.0, Inquisite Inc.) (See Appendix C for the complete online survey).

The survey instrument was piloted by residents at VCU graduate endodontic residency program to determine if the questions were clear and the use of terminology was acceptable. However, the knowledge portion of the questionnaire was poorly proofed. In the pilot survey and subsequent web based survey, the questions directed each participant to "please choose the best

answer to each of the following questions" followed by further instructions to "choose all that apply." Green's survey directed each respondent to "choose the one best answer." The residents at VCU participating in the pilot study did not select more than one correct answer for each question even though the instructions were "choose all that apply." Respondents in the web based survey chose multiple answers for each question.

For instance, the first question in the current survey was as follows:

Please choose the best answer to each of the following questions:

A study wishes to assess facial swelling characteristics in the general population prior to root canal therapy. Patients were evaluated for severity of swelling, location of swelling, age, and race. Which of the following variables describes the appropriate measurement scale or type? **(choose all that apply.)**

#20. _____ Facial swelling measured in centimeters

[ ] discrete

[ ] continuous

[ ] ordinal

[ ] nominal

[ ] dichotomous

In Green's survey, the first question was as follows:

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To compensate for the "choose all that apply" format used, respondents were credited with a correct score if they selected the correct answer or they selected the correct answer with a possible plausible distracter. For example, the correct answer for question #20 is continuous (Table 1). A continuous measurement measures the numerical value that has a continuous value (i.e. age) (19). The plausible distracter or plausible correct answer is discrete. A discrete measurement measures the numerical characteristics that have an integer value (i.e. number of pregnancies) or is defined as the state of being several and distinct independent categories (19). A correct answer was scored if a respondent answered just continuous or answered continuous with the plausible distracter discrete due to the question pertaining to facial swelling measured in the numerical value of centimeters. The following responses are incorrect: ordinal or nominal.

A nominal value pertains to a measurement which does not contain numerical values (i.e. race and gender). An ordinal measurement is used to describe an underlying order to their values and the values may be arbitrary (19).

TABLE 1. Responses and Scoring for Question #20

Question #20 responses	N	Scored as	Reason*
Continuous	15	Correct	1
Continuous and Nominal	1	Incorrect	4
Continuous and Ordinal	5	Incorrect	4
Discrete	4	Incorrect	3
Discrete and Continuous	3	Correct	2
Discrete, Continuous, Ordinal, and Nominal	1	Incorrect	4
Nominal	19	Incorrect	4
Ordinal	10	Incorrect	4
Ordinal and Nominal	2	Incorrect	4

*1 - single best correct answer

2 - correct; plus only a plausible distracter

3 - only plausible distracters

4 - includes an incorrect answer

The remaining survey responses and scoring for each question are in Appendix D. Although the on-line survey was proofed by the investigators (LeTellier and Best), the "dichotomous" response did not appear on the online survey for questions #20, #21, and #22. Only the first four options were actually available in the online survey for these questions.

Results

The survey targeted 230 graduate endodontic residents in 30 accredited endodontic residency programs. Of the 230 surveys sent out via e-mail, 18 were returned as delivery failures. The survey was completed by 68 residents. However, not all 68 residents completed every question in the survey. This accounts for the different response rates observed for every question in the survey. In total, a 32% response rate was achieved. The characteristics of the respondents are shown in Table 2. Of the respondents who completed the survey, 75% were male and 25% were female. The majority of the respondents were age 26-30 (41%) or 31-35 (37%) with either a DDS or DMD degree (59% and 38% respectively). The respondents were primarily enrolled in a two year residency program (78%) in comparison to a three year residency program (19%). Overall, there was an equal percentage of first and second year residents who replied to the survey (46% each) with seven percent of the respondents in the third year of their residency program. Most residents stated they had taken a course in biostatistics (81%). This course was taken during residency (75%). However, 44% of the respondents stated they had not received any training in evidence-based dentistry and 41% stated they had not had any courses in epidemiology. Ninety-nine percent of the respondents stated they regularly read the Journal of Endodontics.

TABLE 2: Demographics of Survey Respondents

Characteristics	N	%
Gender		
Male	51	75
Female	17	25
Age (years)		
21-25	3	4
26-30	28	41
31-35	25	37
36-40	9	13
41-45	2	3
46 and older	1	1
Degrees		
DDS	40	59
DMD	26	38
PhD	1	1
MSc	5	7
MPH/MHS	1	1
Other	7	10
Years since dental school graduation:		
Less than 1	8	12
1-2	13	19
3-4	17	25
5-7	20	30
8 or more	9	13
Current level of training:		
Intern	1	1
1st year resident	31	46
2nd year resident	31	46
3rd year resident	5	7
Residency training program type:		
Two year endodontic residency	53	78
Three year endodontic residency	13	19
Other	2	3

The statistics-related training of the respondents is shown in Table 3.

TABLE 3: Characteristics of Survey Respondents

Characteristic	N	%
Ever taken a course in epidemiology?		
Yes	40	59
No	28	41
If yes, during what part of your education?		
College	8	20
Dental School	19	48
Residency	10	25
Other	3	8
Ever taken a course in biostatistics?		
Yes	55	81
No	13	19
If yes, during what part of your education?		
College	2	4
Dental School	8	15
Residency	41	75
Other	4	7
Ever had a Dental School course in evidenced-based dentistry?		
Yes	38	56
No	30	44
If yes, during what part of your education?		
Dental School	22	59
Residency	13	35
Other	2	5
Which of the following journals do you read		
I do not regularly read journals	1	1
Dentistry Today	5	7
Journal of Endodontics	67	99
International Endodontic Journal	31	46
Oral Surgery, Oral Medicine, Oral	31	46
Other	9	13

The overall mean resident knowledge score was 42.3% (SD, 17.5%; range, 10% to 90%). The number and percentage correct for each item is shown in Table 4. Residents scored highest in question #26 and lowest in question #23. The reliability of the ten item scale was poor

(Cronbach's $\alpha = 0.11$). Cronbach's scale is commonly used to measure the internal consistency or reliability of test scores. Cronbach's number will generally increase as the intercorrelations amongst the test items increases (zero to one scale) (19). The low Cronbach's value obtained in this survey revealed poor internal consistency. Respondents were unable to consistently display biostatistical knowledge which could be applied to correctly answer multiple questions in the survey.

For question #20, 60 responses were received and only 30% of the respondents correctly answered continuous or continuous with the plausible distracter discrete. The respondents 32% of the time stated nominal was the correct answer and 17% of the time stated ordinal was the correct answer. Both these answers were incorrect. For question #20, respondents displayed a poor ability to define facial swelling measured in centimeters as a continuous scale of measurement. For question #21, 60 responses were received and 62% of the respondents correctly identified the correct answer and the plausible distracters. The most common incorrect answer was discrete which was identified by 10% of the respondents. For question #21, the majority of the respondents were capable of identifying the facial swelling classifications of none, moderate, and severe as ordinal, nominal, and discrete. Question #22 was correctly answered 36% of the time by 58 respondents. Again, this question focused on the respondents' ability to correctly identify the scales of measurement. Most respondents (35%) stated the correct answer was discrete while 12% stated the correct response was ordinal. Both responses were incorrect. The knowledge base of the scales of measurement as derived from the low percentage of correct responses on questions #20-#22 shows a poor resident knowledge of biostatistic terms.

Question #23 was the first question posed to determine the residents' knowledge on study designs. Question #23 had 63 responses with only 14% of the responses correctly answering a case-control study. The majority of the respondents stated the study design was a retrospective cohort study (57%) while 13% of the respondents stated the study design was a cross-sectional study. The poor understanding of study designs by the residents resulted in a low percentage of correct responses on question #23. Question #24 continued to determine the residents' knowledge on study designs and 63 responses were received. The retrospective cohort study was correctly answered 44% of the time while the cross-sectional study was incorrectly answered 38% of the time. Again, a poor understanding of the study designs was evident.

Question #25 was a simple question that asked the respondents to define prevalence. Sixty-one responses were received for this question and 69% of the respondents correctly answered the question (answer 1). Answer 3 was second most commonly identified (15%). This answer was the definition for incidence. A confusion regarding the difference between prevalence and incidence was observed among the respondents.

Question #26 was correctly answered 64% of the time by the 64 respondents. The question was again a simple question regarding the principle of a double-blinded study. Confusion was evident by the varying degree of responses observed in question #26. While 64% responded correctly, 36% of the respondents answered nine varying responses to this question. Overall, the knowledge of the principle purpose of a double-blinded study was high.

The last three questions of the survey focused on the p-value. Question #27 analyzed the respondent's knowledge of the definition of p-value. Sixty respondents answered the question

with only 15% of the respondents answering the question correctly. Collectively, 18 different responses were received regarding the correct response for the definition of the p-value. The most common incorrect answers selected were answer 1 (20%) and answer 4 (15%). Question #28 expanded upon the resident's knowledge of the p-value. Fifty-eight respondents answered this question with only 31% of the respondents answering the question correctly. Again, many different responses were received regarding the correct statements about the p-value (11 different responses). The most common incorrect answers selected were answer 2 (22%) and answer 3 (19%). Question #29 is the last question of the survey and again focuses on the p-value. Fifty-eight responses were received for question #29. Unlike the previous 2 questions pertaining to the p-value, the majority of the respondents answered the question correctly (57%). A total of eight different responses were received regarding the correct response to the question. A poor correct response rate on questions #27-29 regarding simple p-value knowledge reveals a deficient knowledge of the p-value by the respondents of the survey.

TABLE 4: Knowledge Items

Knowledge Item	Correct N	Correct Y	%Y
#20 Identify continuous variable	42	18	30
#21 Identify ordinal variable	23	37	62
#22 Identify nominal variable	37	21	36
#23 Recognize a case-control study	54	9	14
#24 Recognize a retrospective cohort study	35	28	44
#25 Recognize the definition of prevalence	19	42	69
#26 Recognize the purpose of a double-blind study	23	41	64
#27 Recognize definition of p-value	51	9	15
#28 Interpret an extremely small p-value	40	18	31
#29 Interpret the meaning of p-value > 0.05	25	33	57
Average			42

The following demographics were screened to determine if there was any relationship with the overall percentage correct. All of the variables in the demographic table, gender ($p = 0.39$), and age ($p = 0.59$) were not related to total knowledge. Conversely, those with a DDS scored higher ($p = 0.032$) than those with a DMD scored ($p = 0.045$). There was no difference associated with any of the other degrees. The total years since obtaining a dental degree was unrelated ($p = 0.23$). The current year of the resident ($p = 0.21$) or whether the endodontic residency was a two- or three-year program displayed no difference in biostatistic knowledge ($p = 0.11$). The respondents who had taken an epidemiology course displayed no difference in biostatistic knowledge ($p = 0.31$) as did those who had taken a biostatics course ($p = 0.60$) or evidence-based dentistry course ($p = 0.85$).

The last portion of the survey attempted to assess the attitude and confidence of the respondents regarding biostatistic knowledge. After statistical analysis of the data, none of the attitude or confidence items correlated with the total knowledge score (p-value > 0.17). Results are listed in Table 4. Nearly all the respondents agreed or strongly agreed (97%) that to be an intelligent reader of the literature it is necessary to know something about statistics. Seventy-three percent of the respondents strongly agreed or agreed they often use statistical information in forming opinions or making treatment decisions. However, only 39% of the respondents stated they strongly agreed or agreed they understood all of the statistical terms encountered in journal articles. This finding is confirmed by the low percentage of questions correctly answered in this survey (42.3%). Furthermore, only 19% of the respondents stated they strongly agreed or agreed that they could interpret a p-value for a given result. This was also confirmed by the low percentage of questions answered correctly about p-value (Questions #27-29). Forty-six percent

of the respondents stated they strongly agreed or agreed they could interpret the results of a statistical method used in research and 68% strongly agreed or agreed they could assess the correct statistical procedure used to answer a research question. The percentage of respondents stating confidence in interpreting biostatistical data appears high considering only 42.3% of the questions were answered correctly in the survey. It is encouraging that 58% strongly agreed or agreed that they would like to learn more about statistics.

Table 5: Attitude and Confidence

	Agreement						
Question	Strongly Agree	Agree	Neither	Disagree	Strongly Agree	Mean	SD
Please answer the following questions regarding statistics or biostatistics:							
Given the chance, I would like to learn more about statistics.	10	29	12	14	2	2.54	1.08
I can understand almost all of the statistical terms that I encounter in journal articles.	2	24	6	30	5	3.18	1.10
Because it is easy to slant results with statistics, I don't trust them at all.	1	9	23	32	2	3.37	0.81
I often use statistical information in forming opinions or making treatment decisions.	5	44	9	8	1	2.34	0.84
To be an intelligent reader of the literature, it is necessary to know something about statistics.	31	34	0	1	1	1.61	0.72
Please rate your confidence in your current level of ability in the following activities:							
Interpreting the p-value for a given result.	2	11	23	15	17	3.50	1.13
Interpreting the results of a statistical method used in research.	7	24	30	4	3	2.59	0.92
Assessing if the correct statistical procedure was used to answer a research question.	17	29	17	2	3	2.19	1.00
Identifying the factors that influence a study's power.	8	25	22	9	4	2.65	1.05

The mean and standard deviation (SD) were calculated using "strongly agree" as a score of 1 and "strongly disagree" as a score of 5.

Discussion

The survey was designed to analyze the graduate endodontic residents' confidence, knowledge, and attitudes toward biostatistics. Yet, the construction of the survey itself was fundamentally flawed. This flaw may allow the survey results to be open for criticism. In constructing the survey, the "choose all that apply" format was used instead of the "choose the one best answer" format. In using the "choose all that apply" format, it became difficult to score right responses from wrong responses or responses which were partly correct. However, this flaw was minor with small differences observed. For example, the correct answer and the plausible distracter were identified by 30% of the respondents in question #20 (Table 1). Twenty-five percent of the respondents identified just the correct answer. In the format of "choose the one best answer", which was employed by Green et al, a 5% difference would be attained in comparison to the current format of this survey which, was "choose all that apply." For this reason, the survey results appear justified.

The survey was completed by 30% of the endodontic residents' questioned. Overall, the survey depicts a low level of knowledge of biostatistics as only 42.3% of the survey questions were correctly answered. The majority of the residents (99%) acknowledged they read the scientific articles in the Journal of Endodontics and stated they employ the use of statistical information in forming opinions in making treatment decisions (73%). Nonetheless, a low biostatistical knowledge base would limit the residents' ability to critically analyze scientific papers for usage in treatment decisions.

The overall results of the current study are similar to the results observed by Green et al (9). Green et al displayed a response rate ranging from 28% to 80% depending on the individual

medical residency program surveyed. The response rate of the current study was 32%. Furthermore, Green et al observed a 41.4% mean overall percentage correct on statistical knowledge by medical residents where the overall percentage correct in the current study was 42.3%. Green et al observed higher scores for medical residents with advanced degrees, prior biostatistics training, enrollment in a university-based training program, and male sex. The results of this survey did not find any correlation between biostatistical knowledge and any of the factors surveyed. Interestingly, 95% of the respondents in the Green et al survey stated they felt it was important to understand biostatistical concepts in order to read scientific papers. A similar result was observed in the current survey where 97% of the respondents stated it was important to know something about statistics in order to be an intelligent reader of the literature. Green et al concluded most medical residents lack the knowledge in biostatistics required to interpret many of the results in published clinical research (9). A similar conclusion can be drawn regarding endodontic residents based on the low overall percentage correct.

The low level of knowledge of biostatistics by endodontic residents found in this study is consistent with the results of previous studies. The results of studies analyzing the biostatistical knowledge of practicing medical physicians in the 1980s showed most physicians possessed a poor understanding of common statistical tests and displayed a limited ability to interpret study results (9-12). A 2009 survey of Italian physicians revealed that only 50.8% of the respondents were able to correctly identify more technical biostatistic related questions. A low level of knowledge of biostatistics was evident. More interesting, most Italian physicians did not incorporate the use of meta-analysis results into their clinical practice (14). In 1987, a survey of fifth year surgical residents found that the surgical residents' maintained a suboptimal knowledge

of statistics (15,16). A follow-up study in 2000 analyzed a structured curriculum for improved resident education in statistics and evidence-based medicine knowledge. The authors concluded that a structured curriculum in statistics was critical and essential to any residency's core curriculum and to the resident's success in practicing evidence based medicine (16). Insufficient training in the field of biostatistics likely reflects the poor knowledge level and poor confidence level observed in graduate endodontic residents. With an improved curriculum focusing on biostatistics, improved biostatistic knowledge and confidence may be obtained.

With a poor understanding of biostatistics, residents may be unable to apply evidence-based dentistry into their clinical applications. Furthermore, incorrect interpretation of data may lead to erroneous applications of clinical research. As an example, in a recent article published in the Journal of Endodontics in 2008, the authors evaluated the efficacy of revascularization in 14 cases of infected, immature teeth. They reported the following outcomes; "Radiographic resolution of periradicular radiolucencies was judged to be good to excellent in 93% (13 of 14) of the cases. In the majority of cases, a narrowing of the wide apical opening was evident. In 3 cases, thickening of apical dentinal walls and increased root length were observed. The striking finding was complete resolution of clinical signs and symptoms and appreciable healing of periapical lesions in 78% (11 of 14) of cases. Thickening of lateral dentinal walls was evident in 57% (8/14) of cases, and increased root length was observed in 71% (10/14) of cases. None of the cases presented with pain, reinfection, or radiographic enlargement of preexisting apical pathology. This pilot study documented a favorable outcome of revascularization procedures conducted in immature nonvital, infected permanent teeth" (20). The authors' results and conclusions were called into question by Dr. Messer. He stated the radiographs did not support

the findings of the study and no criteria for the subjective ratings of the radiographs were included in the article. He further states "a more realistic assessment of the outcome of this study is that revascularization is not a predictably successful procedure in cases with long-standing pulp necrosis plus acute or chronic apical periodontitis, without the inductive potential of mineral trioxide aggregate" (21). A poor understanding of biostatisitcs may force residents to rely on peer reviewed journals for evidence based-dentistry whether correct or incorrect conclusions are drawn and published. If residents are well versed in biostatistics, incorrect application of clinical information may be avoided. One way to increase resident knowledge of biostatistics during residency may be to focus on journal clubs with an evidence-based focus.

The purpose of this study was to assess the level of understanding of biostatistic applications and analyses among endodontic residents in the United States. The hypothesis, that there exists a significant lack of understanding of biostatistical principles within this group, was found to be true. The poor understanding of biostatistic knowledge was confirmed in the study. Endodontic resident's ability to correctly analyze and understand biostatistical results is questionable. An improved understanding and confidence in biostatistics is desirable.

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Appendix A

Letter of Invitation for the Survey to Endodontic Program Directors

To Whom It May Concern,

My name is Dr. Paul LeTellier. I am currently a second year endodontic resident at Virginia Commonwealth School of Dentistry Graduate Endodontic Department. In conjunction with the Department of Biostatistics, we would like to conduct a survey of endodontic residents' understanding of biostatistics as it pertains to the dental literature. In order to accomplish this survey, I will require the e-mail addresses of current endodontic residents in order to include each resident in the survey. The e-mails will only be used for the survey and for no other purposes. Your participation in releasing the e-mails is voluntary. The residents do not have to participate in this survey. If the residents choose to participate, a resident may stop at any time without any penalty. A resident may also choose not to answer particular questions that are asked in the study. If the residents desire to participate in the survey, can you please e-mail a list of each resident's e-mail address to pjrletellier@gmail.com or letellierjpr@vcu.edu. I would greatly appreciate it. If you have any questions or reservations, please e-mail me at the above addresses. Thank you for your time and have a good day.

Sincerely,

Paul LeTellier DDS

Second Year Resident VCU Grad Endo

And

Karan J. Replogle, DDS, MS
Assistant Professor
Interim Program Director Advanced Education Program in Endodontics
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Appendix B

Introduction Letter for Survey to Graduate Endodontic Residents

Dear Endodontic Colleague,

My name is Dr. Paul LeTellier and I am a second year resident at Virginia Commonwealth University School of Dentistry. In conjunction with the Virginia Commonwealth University Department of Biostatistics, we are conducting a survey to determine the endodontic resident's knowledge of biostatistics. The survey results should help program directors design a biostatistics curriculum that best meets the needs of current residents.

The survey is anonymous and totally voluntary. You do not have to participate in this survey. If you choose to participate, you may stop at any time without any penalty. You may also choose not to answer particular questions that are asked in the survey.

We greatly appreciate your help with this project and would be pleased to share the results with you when the study is completed. If you have questions or comments regarding the survey, please e-mail letellierjpr@vcu.edu.

Kindest regards,

Karan J. Replogle DDS, Program Chair Advanced Program in Endodontics

And

Paul LeTellier DDS, MS, Second Year Resident
Department of Endodontics Virginia Commonwealth University School of Dentistry
Richmond, VA

Appendix C

Biostatistics Confidence & Knowledge Test Survey Instrument

Please answer the following questions:

1. Gender:

( ) Male

( ) Female

2. Age:

( ) 21-25

( ) 26-30

( ) 31-35

( ) 36-40

( ) 41-45

( ) 46 and older

3. Advanced Degrees #check all that apply#:

[ ] DDS

[ ] DMD

[ ] PhD

[ ] MSc

[ ] MPH/MHS

[ ] Other _____

4. Years since dental school graduation:

( ) less than 1

( ) 1-2

( ) 3-4

( ) 5-7

( ) 8 or more

5. Current level of training:

( ) Intern

( ) 1st year resident

( ) 2nd year resident

( ) 3rd year resident

6. Residency training program type:

( ) Two year endodontic residency

( ) Three year endodontic residency

( ) Other _____

7. Ever taken a course in epidemiology?

( ) Yes

( ) No

7a. If yes, during what part of your education?

( ) College

( ) Dental School

( ) Residency

( ) Other _____

8. Ever taken a course in biostatistics?

( ) Yes

( ) No

8a. If yes, during what part of your education?

( ) College

( ) Dental School

( ) Residency

( ) Other _____

9. Ever had a Dental School course in evidenced-based dentistry?

( ) Yes

( ) No

9a. If yes, during what part of your education?

( ) Dental School

( ) Residency

( ) Other _____

10. Which of the following journals do you read regularly?
Check all that apply:

[ ] I do not regularly read journals

[ ] *Dentistry Today*

[ ] *JADA*

[ ] *Journal of Endodontics*

[ ] *International Endodontic Journal*

[ ] *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology*

[ ] Other _____

Please answer the following questions regarding statistics or biostatistics:	Strongly Agree	Agree	Neither	Disagree	Strongly Disagree
11. Given the chance, I would like to learn more about statistics.	1	2	3	4	5
12. I can understand almost all of the statistical terms that I encounter in journal articles.	1	2	3	4	5
13. Because it is easy to slant results with statistics, I don't trust them at all.	1	2	3	4	5
14. I often use statistical information in forming opinions or making treatment decisions.	1	2	3	4	5
15. To be an intelligent reader of the literature, it is necessary to know something about statistics.	1	2	3	4	5

Please rate your <u>confidence</u> in your current level of ability in the following activities:	None	A Little	Fair Amount	A Lot	Complete Confidence
16. Interpreting the p-value for a given result.	1	2	3	4	5
17. Interpreting the results of a statistical method used in research.	1	2	3	4	5
18. Assessing if the correct statistical procedure was used to answer a research question.	1	2	3	4	5
19. Identifying the factors that influence a study's power.	1	2	3	4	5

Please choose the best answer to each of the following questions:

A study wishes to assess facial swelling characteristics in the general population prior to root canal therapy. Patients were evaluated for severity of swelling, location of swelling, age, and race. Which of the following variables describes the appropriate measurement scale or type? (choose all that apply.)

20. _____ Facial swelling measured in centimeters

[ ] discrete

[ ] continuous

[ ] ordinal

[ ] nominal

[ ] dichotomous

21. _____ Facial swelling classified as none, moderate, severe

[ ] discrete

[ ] continuous

[ ] ordinal

[ ] nominal

[ ] dichotomous

22. _____ Type of evaluation classified as observational, manual, or photographic

[ ] discrete

[ ] continuous

[ ] ordinal

[ ] nominal

[ ] dichotomous

23. To determine if malnutrition is associated with flare ups after non surgical root canal therapy, data from 40 patients with flare ups were collected. These patients were matched for age, sex, and race to 40 patients without flare ups. The dental charts of these patients were then reviewed to determine their nutritional status. This study type is known as:

[ ] Cross-sectional study

[ ] Concurrent cohort study

[ ] Case-control study

[ ] Retrospective cohort study

[ ] Randomized clinical trial

To determine the prevalence of endodontically treated teeth in Brazilian adults, data from panoramic radiographs from 1,401 patients were analyzed. The panoramic radiographs were collected from a radiologic center between August 2002 and September 2007. They were analyzed for the presence of partially or completely filled canal spaces, the presence of intracanal post, and associated apical periodontitis.

24. This study type is known as:

[ ] Cross-sectional study

[ ] Concurrent cohort study

[ ] Case-control study

[ ] Retrospective cohort study

[ ] Randomized clinical trial

25. Which of the following statement(s) are true concerning prevalence? (choose all that apply.)

[ ] Proportion of people who have a given disease or condition at a specified point in time

[ ] Number of new cases that have occurred during a given interval of time divided by the population at risk at the beginning of the time interval

[ ] Number of individuals who develop a disease in a given period of time divided by the number of people in the population at risk

[ ] Prevalence involves a period of time and is actually a proportion

[ ] Prevalence does not involve a period of time and is not a proportion

26. The purpose of a double-blind or double-masked study is to:

[ ] Achieve comparability of treated and untreated subjects

[ ] Reduce the effects of sampling variation

[ ] Avoid observer and subject bias

[ ] Avoid observer bias and sampling variation

A study was performed to analyze the clinical efficacy of 2% CHX gel on bacterial reduction during root canal therapy. Bacterial samples were taken upon access, after instrumentation using 2% CHX as a disinfectant, and after 2 weeks of using 2% CHX as an intracanal dressing. A significant difference in the percentage of positive cultures between samples taken upon access and samples taken after instrumentation was found ($p<0.001$). However, no significant difference was found in the percentage of positive cultures taken after instrumentation and after using 2% CHX as intracanal dressing for 2 weeks ($p=0.692$).

27. Which of the following statements are true? (choose all that apply.)

[ ] The p-value is the probability of the sample data arising by chance

[ ] The p-value is an arbitrary value, designated as the significance level.

[ ] The p-value is the chance of getting an observed effect if the null hypothesis was false.

[ ] The p-value is the chance of getting an observed effect if the null hypothesis was true.

[ ] A very small p-value allows us to say that there is enough evidence to accept the null hypothesis.

28. Which of the following statements is correct? (choose all that apply.)

[ ] An extremely small p-value indicates that the actual data differs markedly from that expected if the null hypothesis were true.

[ ] The p-value measures the probability that the hypothesis is true.

[ ] The p-value measures the probability of making a Type II error. ( ) The larger the p-value, the stronger the evidence against the null hypothesis.

[ ] A large p-value indicates that the data is consistent with the alternative hypothesis.

29. In a placebo-controlled trial to analyze the bacterial count after use of a 17% EDTA as an irrigant during root canal therapy, 88% of patients receiving the treatment displayed a reduction in the bacterial count during root canal therapy. Eighty-nine percent of patients receiving the placebo displayed a reduction in the bacterial load. In reporting this finding, the authors stated that $P > 0.05$. This means:

[ ] The chances are greater than 1 in 20 that a difference would be found again if the study were repeated.

[ ] The probability is less than 1 in 20 that a difference this large could occur by chance alone.

[ ] The probability is greater than 1 in 20 that a difference this large could occur by chance alone.

[ ] The chance is 95% that the study is correct.

Thank you! Press the submit button, below.

Appendix D

Survey Responses and Scoring of Individual Questions

Question #21. _____ Facial swelling classified as none, moderate, severe

[ ] discrete

[ ] continuous

[ ] ordinal

[ ] nominal

[ ] dichotomous

In #21, the question was trying to assess the respondent's ability to define the facial swelling classifications of none, moderate, and severe as the ordinal scale of measurement. The correct answer was ordinal as the measurements are categorized in a well-ordered set (Table 6) (19). The plausible distracters were nominal and discrete. A discrete value is defined as the state of being several and distinct independent categories which pertains to none, moderate, and severe classifications (19). Nominal was accepted as a distracter as it is used for characteristics that have no numerical values (i.e. race and gender) as described by the categories of none, moderate, and severe (19). A response of continuous was not accepted as a correct answer or a plausible distracter.

TABLE 6. Responses and Scoring for Question #21

Question #21 responses	N	Scored as	Reason*
Continuous	1	Incorrect	4
Continuous and Ordinal	1	Incorrect	4
Continuous, Ordinal, and Nominal	1	Incorrect	4
Discrete	8	Incorrect	3
Discrete and Nominal	2	Incorrect	3
Discrete and Ordinal	3	Correct	2
Nominal	10	Incorrect	3
Ordinal	31	Correct	1
Ordinal and Nominal	3	Correct	2

Question #22. _____ Type of evaluation classified as observational, manual, or photographic

[ ] discrete

[ ] continuous

[ ] ordinal

[ ] nominal

[ ] dichotomous

For question #22, a correct answer of nominal was accepted and the plausible distracter of discrete was accepted (Table 7). Continuous and ordinal were not accepted as correct answers or plausible distracters. The classification of observational, manual, or photographic are measurements that have no numerical values (nominal) and can be defined as distinct independent categories (discrete) (19).

TABLE 7. Responses and Scoring for Question #22

Question #22 responses	N	Scored as	Reason*
Continuous	7	Incorrect	4
Discrete	20	Incorrect	3
Discrete and Continuous	2	Incorrect	4
Discrete and Nominal	4	Correct	2
Nominal	17	Correct	1
Ordinal	7	Incorrect	4
Ordinal and Nominal	1	Incorrect	4

Question #23. To determine if malnutrition is associated with flare ups after non surgical root canal therapy, data from 40 patients with flare ups were collected. These patients were matched for age, sex, and race to 40 patients without flare ups. The dental charts of these patients were then reviewed to determine their nutritional status. This study type is known as:

[ ] Cross-sectional study

[ ] Concurrent cohort study

[ ] Case-control study

[ ] Retrospective cohort study

[ ] Randomized clinical trial

A case control study is the correct answer for question #23 (Table 8). A case control study involves identifying and comparing patients who have an outcome of interest (cases) and control patients without the same outcome (19). The two outcomes are then analyzed retrospectively to observe if they had the exposure of interest. The study in question #23 compares patients with flare-ups to patients without flare-ups to determine if a specific exposure (nutritional status) occurs more in flare-ups than in controls. The study is not a randomized

clinical trial. The study is not a retrospective cohort study. A cohort study analyzes a single group of subjects over a course of time (19). The study in question #23 analyzes two groups (flare-up vs. control group). A cross sectional study analyzes a set of subjects at one point in time (19). The above question focuses on a review of charts over the course of time. The study is also not a concurrent cohort study. According to Dawson and Trapp's *Basic and Clinical Biostatistics*, this term does not exist (19).

TABLE 8. Responses and Scoring for Question #23

Question #23 responses	N	Scored as	Reason*
Case-control	9	Correct	1
Concurrent cohort study	4	Incorrect	4
Concurrent cohort study and Retrospective cohort study	1	Incorrect	4
Cross-sectional	8	Incorrect	4
Cross-sectional study and Case-control study	1	Incorrect	4
Cross-sectional study and Retrospective cohort study	4	Incorrect	4
Retrospective cohort study	36	Incorrect	3

Question #24. To determine the prevalence of endodontically treated teeth in Brazilian adults, data from panoramic radiographs from 1,401 patients were analyzed. The panoramic radiographs were collected from a radiologic center between August 2002 and September 2007. They were analyzed for the presence of partially or completely filled canal spaces, the presence of intracanal post, and associated apical periodontitis. This study type is known as:

[ ] Cross-sectional study

[ ] Concurrent cohort study

[ ] Case-control study

[ ] Retrospective cohort study

[ ] Randomized clinical trial

For question #24, the correct answer is a retrospective cohort study (Table 9). The study was performed retrospectively to assess a single group of subjects over a course of time (19). The remaining answers were not accepted as correct other than retrospective cohort study.

TABLE 9. Responses and Scoring for Question #24

Question #24 responses	N	Scored as	Reason*
Case-control	4	Incorrect	4
Concurrent cohort study	1	Incorrect	4
Cross-sectional	24	Incorrect	4
Cross-sectional study, Case-control study, and Retrospective cohort	1	Incorrect	4
Cross-sectional study and Retrospective cohort study	5	Incorrect	4
Retrospective cohort study	28	Correct	1

Question #25. Which of the following statement(s) are true concerning prevalence? (choose all that apply.)

[1] Proportion of people who have a given disease or condition at a specified point in time

[2] Number of new cases that have occurred during a given interval of time divided by the population at risk at the beginning of the time interval

[3] Number of individuals who develop a disease in a given period of time divided by the number of people in the population at risk

[4] Prevalence involves a period of time and is actually a proportion

[5] Prevalence does not involve a period of time and is not a proportion

According to Dawson and Trapp, prevalence is the proportion of people who have a given disease or condition at a specified point in time (19). It is not a rate (19). For question #25, answer 1 is the only correct response (Table 10). Answer 3 is a plausible distracter as prevalence can be defined as the number of individuals with a given disease at a given point in time divided by the population at risk for that disease at that time (19). However, the plausible distracter was not paired with the correct answer 1 during the survey. For this reason, it was not counted as a correct answer. Prevalence does not involve a period of time and is a proportion. Answers 4 and 5 were not counted for these reasons. Answer 2 pertains to incidence and not to prevalence.

TABLE 10. Responses and Scoring for Question #25

Question #25 responses	N	Scored as	Reason*
2	1	Incorrect	4
2,3	1	Incorrect	4
2,3,4	1	Incorrect	4
3	9	Incorrect	4
3,4	5	Incorrect	4
1	42	Correct	1
1,2	2	Incorrect	4

Question #26. The purpose of a double-blind or double-masked study is to:

[1] Achieve comparability of treated and untreated subjects

[2] Reduce the effects of sampling variation

[3] Avoid observer and subject bias

[4] Avoid observer bias and sampling variation

The correct answer to question #26 was answer 3 (Table 11). The plausible distracter to question #26 was answer 1. The primary goal of a double-blinded or double-masked study is to avoid observer bias and subject bias (19). A double-blinded study can also be used to accomplish the comparability of treated and untreated subjects (19). Answer 2 and 4 are incorrect as the goal of a double blinded study is not to reduce the effect of sampling variation.

TABLE 11. Responses and Scoring for Question #26

Question #26 responses	N	Scored as	Reason*
3	27	Correct	1
4	3	Incorrect	4
3,4	8	Incorrect	4
1	1	Incorrect	3
1,3	14	Correct	2
1,3,4	3	Incorrect	4
1,4	1	Incorrect	4
1,2,4	2	Incorrect	4
1,2,3,4	5	Incorrect	4

Question #27. A study was performed to analyze the clinical efficacy of 2% CHX gel on bacterial reduction during root canal therapy. Bacterial samples were taken upon access, after instrumentation using 2% CHX as a disinfectant, and after 2 weeks of using 2% CHX as an intracanal dressing. A significant difference in the percentage of positive cultures between samples taken upon access and samples taken after instrumentation was found ($p<0.001$). However, no significant difference was found in the percentage of positive cultures taken after instrumentation and after using 2% CHX as intracanal dressing for 2 weeks ($p=0.692$).

Which of the following statements are true? (choose all that apply.)

[1] The p-value is the probability of the sample data arising by chance

[2] The p-value is an arbitrary value, designated as the significance level.

[3] The p-value is the chance of getting an observed effect if the null hypothesis was false.

[4] The p-value is the chance of getting an observed effect if the null hypothesis was true.

[5] A very small p-value allows us to say that there is enough evidence to accept the null hypothesis.

For question #27, the correct answer is answer 4 (Table 12). Dawson and Trapp define p-value as the probability of observing a result as extreme than the one actually observed from chance alone if the null hypothesis is true (19). The plausible distracter is answer 1. Answer 2, 4, and 5 are incorrect responses.

TABLE 12. Responses and Scoring for Question #27

Question #27 responses	N	Scored as	Reason*
1	12	Incorrect	3
1,2	3	Incorrect	4
1,2,5	1	Incorrect	4
1,2,4	4	Incorrect	4
1,2,4,5	1	Incorrect	4
1,3	5	Incorrect	4
1,3,5	1	Incorrect	4
1,5	2	Incorrect	4
1,4	7	Correct	2
2	4	Incorrect	4
2,3	1	Incorrect	4
2,3,5	1	Incorrect	4
2,4	2	Incorrect	4
3	3	Incorrect	4
3,4	1	Incorrect	4
5	9	Incorrect	4
4	2	Correct	1
4,5	1	Incorrect	4

Question #28. Which of the following statements is correct? (choose all that apply.)

[1] An extremely small p-value indicates that the actual data differs markedly from that expected if the null hypothesis were true.

[2] The p-value measures the probability that the hypothesis is true.

[3] The p-value measures the probability of making a Type II error. ( ) The larger the p-value, the stronger the evidence against the null hypothesis.

[4] A large p-value indicates that the data is consistent with the alternative hypothesis.

For question #28, the only correct answer is answer 1 (Table 13). The p-value does not measure the probability the null hypothesis is true, does not measure the probability of making a type II error, and does not indicate the data is consistent with the alternative hypothesis (19). Answer 2, 3, and 4 are incorrect for these reasons.

TABLE 13. Responses and Scoring for Question #28

Question #28 responses	N	Scored as	Reason*
2	13	Incorrect	3
2,3	1	Incorrect	4
2,3,4	1	Incorrect	4
2,4	3	Incorrect	4
3	11	Incorrect	4
3,4	2	Incorrect	4
4	3	Incorrect	4
1	18	Correct	1
1,2	3	Incorrect	4
1,3	1	Incorrect	4
1,4	2	Incorrect	4

Question #29. In a placebo-controlled trial to analyze the bacterial count after use of a 17% EDTA as an irrigant during root canal therapy, 88% of patients receiving the treatment displayed a reduction in the bacterial count during root canal therapy. Eighty-nine percent of patients receiving the placebo displayed a reduction in the bacterial load. In reporting this finding, the authors stated that P > 0.05. This means:

[1] The chances are greater than 1 in 20 that a difference would be found again if the study were repeated.

[2] The probability is less than 1 in 20 that a difference this large could occur by chance alone.

[3] The probability is greater than 1 in 20 that a difference this large could occur by chance alone.

[4] The chance is 95% that the study is correct.

The correct answer to question #29 is answer 3 (Table 14). There is no plausible distracter for this question. For answer 1, the p-value does not determine if the

difference will be found again if the study were repeated. The p-value does not mean the study is 95% correct so answer 4 is incorrect. Answer 2 is also incorrect as the probability is greater than 1 in 20 that a difference this large could occur by chance alone, not less than 1 in 20.

TABLE 14. Responses and Scoring for Question #29

Question #29 responses	N	Scored as	Reason*
1	5	Incorrect	4
1,4	1	Incorrect	4
1,3	2	Incorrect	4
2	7	Incorrect	4
2,4	1	Incorrect	4
4	8	Incorrect	4
3	33	Correct	1
3,4	1	Incorrect	4

VITA

Paul Robert LeTellier Jr. DDS, MS was born in Gallup, New Mexico, March 5, 1978. He is currently a citizen of the United States of America. He completed high school in Mobile, AL at McGill Toolen High School. He attended Loyola University of New Orleans for his undergraduate studies and graduated with a BS in Biology in 2000. Upon graduation, he attended graduate school at Old Dominion University where he graduated with a MS in biology with thesis in 2005. He then attained a DDS from VCU School of Dentistry in 2007 followed by a Certificate in Advance Education in General Dentistry from VCU School of Dentistry in 2008. In 2008, he began the Advanced Education Program in Endodontics at VCU School of Dentistry and will graduate in 2010 with a Master of Science in Dentistry and a Certificate in Endodontics. He will practice the specialty of endodontics in Sugarland, TX.